



Plan View Showing Disposition of Armament on a Diesel Engine Warship.

advantage of clear vision when fighting an action to leeward is readily recognized.

12. Of the greatest importance would be the abolition of the huge smokestack itself. The peril of a shell exploded in the stack, hurling its fragments down the uptakes, thus cutting boiler tubes and scalding firemen, has for long been a much talked of danger. Generally it is agreed that in this way alone could an aeroplane do material damage to a modern dreadnought.

Most striking is the actual case of the Russian battleship "Tsarvitch," in the battle of Round Island. Her smoke stacks were badly torn by exploding shells, with the result that the coal consumption was increased sixfold, compelling the crew to intern a powerful unit, otherwise possessing splendid fighting qualities, in a Chinese port, where she was of as little use to the Russians as if on the planet Mars.

That this incident commanded earnest thought and consideration is shown by the armor, most pronounced in the Oklahoma class, now protecting the base of the

stacks in our dreadnoughts. But such armoring has only lessened the degree of weakness, while making the elimination of the stack more desirable.

13. When doing station, as in blockades, fleets are often steaming at much reduced speed. At such times coal economy limits the number of boilers in use. Under these conditions it requires time to break fires necessary to getting under full headway, which delay may be of great advantage to the enemy. In an oil-engined ship, on the other hand, full power is almost instantaneously available, thus greatly increasing the mobility.

14. The absence of the "Massachusetts" from the battle line at Santiago illustrates what coaling means in the presence of the enemy. The use of oil should make the operation of taking on fuel much safer in open waters.

15. From the military standpoint the abolition of smokestacks, uptakes, boilers, etc., would give a much greater arc of train for the big guns by permitting a better disposition of the turrets. Moreover the increasing power of torpedo craft may make the greater deck space avail-

able for all secondary guns of paramount importance.

16. Following closely the line of this argument, a greater isolation of the magazines and vital parts of the ship would be possible, together with a more complete subdivision of the hull.

17. Such concentration of the propelling machinery would make practicable a system of under-water armoring, against torpedo attacks, similar to that embodied in the "Henry IV" of the French navy.

18. Oil can be easily stowed in the double bottom of the ship. Thus at once is obviated that difficulty in reaching the coal, so noticeable in the Japanese "Soya," yet appearing to a lesser degree in many ships.

The accompanying illustrations clearly show the possibilities of heavy concentrated protection, great all-round fire and symmetrical distribution of weights resulting from the use of the heavy-oil Diesel engine. It must not be expected that our next warships will be so equipped, but rather that, at a time not far distant, these great possibilities may be realized.

## Conservation and Research\*

### Economies Secured by Scientific Investigation

By Herbert T. Kalmus

WE are all impressed in these times with the increasing importance of our problems of conservation, and we regard with extreme pleasure the active and vigorous steps which the various governments have taken, and are taking, to insure that there be a minimum of waste in obtaining our raw materials. To most persons conservation means to draw upon nature for our supply of the various natural products that we require, in such a manner that posterity may not complain that we have been unduly wasteful or extravagant. The fundamental importance of this kind of conservation is very generally recognized, and I shall dwell upon it only in passing, but there is another type of conservation, less recognized, but equally important, of which I wish particularly to speak. This is the conservation resulting from scientific investigation and research.

On this continent we have acquired the habit of being well satisfied with what we have accomplished. We marvel at our enterprise in scraping iron ore from the earth's surface by steam shovels and in growing wheat and cotton on virgin soil, in stripping great areas of primeval forest and in allowing petroleum to spout from the ground. We cut more ice along a few hundred miles of our northeastern shore in one month than all the Pictet machines in France can turn out in a year, and we control the copper and nickel markets of the world because nature has given us copper and nickel. If you want cheap sulphur you must come to us, for we pump it from the ground, and we develop great centers of power distribution because our rivers run so rapidly down hill. To these vast resources we have applied a native energy and genius, in certain respects probably unequalled by any other people, but nevertheless, what we do on this great scale we often do wastefully and extravagantly. Is it not time for us to pause in our progress to inquire whether things might not be better done, whether indeed the more conservative methods of other nations, given equal opportunity, might not put our own performance to shame?

Most of the materials extracted from the earth have been exploited for thousands of years. However, the drafts upon the reserves of the earth as compared with its total capacity were small until the beginning of the nineteenth century. From the dawn of civilization until that time, the amounts of minerals and metals mined had been so inconsiderable that it was thought that they would last through the indefinite future. Toward the latter half of the nineteenth century began the age of scientific advance and invention and of industrial and commercial operation on a large scale.

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Forecasts of the life of mineral resources made prior to that time became worthless in view of the tremendous acceleration at hand. Indeed, on this continent the output of the all important products, coal and iron, has approximately doubled in ten years, or looking back further, the output of the first decade of this century has been more than that of all previous decades.

In his presidential address before the British Association for the Advancement of Science, Sir William Ramsay stated that if the present increase in the output of coal mines in the British Isles continued, the supply would be exhausted in 175 years, a very brief space in the life of a nation. More recently the time has been extended, owing to the discovery of new coal areas, but it is by no means unlimited. On this continent the coal supply is more nearly unlimited, but even here, if we take into account the increasing uses for it, and if we have in mind coal which can as readily be mined as is the case at present, we can hardly contemplate the future without concern. In the year 1910 there were mined about 1,300,000,000 tons of coal. Of this, over 40 per cent was produced on this continent, and yet, according to Dr. J. A. Holmes, Director of the U. S. Bureau of Mines, more than 2,000,000,000 tons of anthracite coal and more than 3,000,000,000 tons of bituminous coal have been left underground in such condition as to make their future recovery doubtful or impossible. That there is tremendous waste in the mining of fuel supplies in North America is generally recognized, but its magnitude is beyond comprehension. In the mining of coal probably not 50 per cent of it is removed from the ground and brought into a form such that it can be economically utilized.

It is with this type of conservation, that of reducing waste in connection with reaping the various harvests of nature, that the governmental commissions have had primarily to do. We are glad that the work is being so well done, and that we are being so abundantly informed of it through the various governmental publications. However, this is but one aspect of conservation. It is not sufficient that we cut our timbers with as little waste as possible, and in such a manner that they may grow again; it is not enough that we legislate against removing that portion of the coal which is most easily removed, which yields immediate high financial return but which leaves a large fraction buried for all time; it is not enough that we devote ourselves solely to the economy of production of raw materials, once they are at hand. Economical production and efficient utilization are in series as are two links of a chain, they are equally important. Surely it must be appreciated that the more efficient utilization of any material

must react to cause us to draw upon nature to a lesser extent for that particular product, and hence, quite as truly as diminishing wastes in the first production of the material, it effects a real conservation.

These latter conservations are usually brought about, directly or indirectly, as the result of painstaking experimental investigations of scientific men, engineers, physicists, chemists, metallurgists, etc., in their various laboratories and practices. Without attempting to select the most important of these, even of those of very recent date, let me illustrate with a few typical instances.

Consider the chemist at work in his laboratory studying the solubility of boiler scale. It is estimated that boiler scale in the locomotives of this continent alone causes an annual loss of over 16,000,000 tons of coal. One sixteenth of an inch of boiler scale means a loss of 13 per cent in efficiency, and one eighth of an inch of boiler scale, which occurs in many boilers, means a loss of 25 per cent in efficiency. Thanks to the work of the research chemist, the deposition of these scales has been reduced and reduced, until now they assume but a small fraction of their former significance. In this way, but so as not to be generally noticed, has the research chemist effected an important conservation of our coal supplies.

You will probably remember that not many years ago, the name of the metal tungsten was unknown to you. Even for the chemist it was a curiosity. At present not only are we familiar with the metal tungsten, but our homes and our offices are lighted with incandescent lamps, the filaments of which are fine drawn tungsten wires. Dr. W. R. Whitney and his associates at the Research Laboratories of the General Electric Company have studied this metal for several years, but it is only comparatively recently that they have succeeded in producing it in a state of ductility such that it could be properly drawn into fine wires. These tungsten lamps are a great improvement on the old carbon filament, for they radiate the same amount of light at about one half the cost, which, translated in terms of conservation, means that they have effected a direct wholesale saving of coal for all time.

It is interesting to note the way in which researches on tungsten have effected real conservations in other ways. This hitherto almost worthless element has been found, when properly formed, to have properties far superior to those of any known metal for the manufacture of X-ray tubes. In modern X-ray practice powerful electrical apparatus is used to excite the tube. The greater part of the energy delivered to the tube is transformed into heat at the point where the cathode rays bombard a metallic target. Where platinum is

used, which melts at 1,780 deg. Cent., it has been found necessary, in order to prevent melting, to place the target beyond the focus of the cathode, so as to spread the bombardment over a larger area. Without going into detail, this means at best an X-ray picture with poor definition due to the danger of melting the platinum. Tungsten, with a melting point of 3,000 deg. Cent., permits of sharp focussing of the rays on the target and of the use of more energy through the tube, and consequently of a shorter exposure than has been hitherto possible. Aside from the direct value of this research to humanity, it will obviously substitute a new metal for the very limited and most costly one hitherto used, platinum, thus conserving the platinum for other uses where it alone can fulfill the requirements. The significance of this becomes obvious when we reflect that the demand for platinum and its relatively diminished production, has caused its price to soar from twenty dollars an ounce troy in 1908 to forty-eight dollars an ounce troy in 1912.

Ages ago there were stored up, chiefly by the influence of plant life, immense deposits of carbon and nitrogen, which have made modern civilization possible. Some of this nitrogen may have been compounded to its present useful form by electrical discharges in the atmosphere, but it is highly probable that the larger portion of it was formed of bacterial action. Certainly it appears to be true, that the 500,000,000 tons of sodium nitrate, which are known to be deposited in the desert of Atacama, Chili, are of organic origin, from plants and animals whose refuse, under peculiar conditions of heat and water supply, was oxidized and collected in this unique locality. Until recently, we have drawn from these deposits practically our total supply of the element nitrogen, which is absolutely essential for both plant and animal food. Besides, we have drawn from this source all of the nitrogen without which we could not have explosives, upon which depends the whole of our mining industry. Our waste of nitrate as fertilizer has so impressed the human mind that the daily press for years has pointed out the possible starvation of man because of the inability of the earth to supply nitrate for plant life. About two and one half million tons of sodium nitrate are being taken each year from Chili, a fact which means that the probable time of depletion of these deposits is less than a century away. Call it two centuries if you like, or five, the principle is the same. Yet, in the manufacture of coke for various industries during a recent period, but \$3,800,000 worth of \$160,000,000 worth of recoverable nitrogen, which the original coal contained, was saved. The balance went off into the air as free nitrogen. This nitrogen, among other things, has been saved by the Germans under similar conditions for a number of years, and is now being saved on this continent to a very rapidly increasing extent, as the result of the development of new metallurgical ovens and new chemical processes.

In comparatively recent years a vast amount of research has been carried on, principally in Germany, the outcome of which has been the development of the wonderful coal tar industry. This industry, which is probably the greatest single example of chemical progress, has as yet not been developed on this continent. It has effected conservations in many ways of which I shall recall but a single one. Among the valuable by-products of this industry are materials from which are prepared an endless variety of dyes and coloring substances. All the aniline dyes are made from distillation products from coal. These formerly required rich land now devoted to other purposes. Indigo alone, now prepared from coal tar, is equivalent to over 300,000 acres of indigo plants.

To me there is no novel more interesting nor story of adventure more fascinating than accounts published

during the last few months of the work of Prof. Haber, which has resulted in the preparation of the nitrogen compound ammonia directly from the nitrogen of the air. At first obtaining only microscopic quantities of his product, later finding that the process was poisoned by minute traces of impurities which it seemed impossible to remove, obliged to work at extremely high temperatures and at very great pressures, and beginning a study which had been given up as impossible by dozens of prominent scientists in the past, Prof. Haber and his research associates are now able to announce that the problem has been fully solved on a manufacturing scale and that the walls of their first factory for synthetic ammonia are already rising above ground. Henceforth man will be able to prepare fertilizers to enrich his soil directly from the atmosphere which everywhere surrounds him.

A number of thoughtful scientists are expressing the opinion that the future will be the age of iron and aluminium. These seem to be provided by nature in practically inexhaustible quantities, but our methods of working their ores to produce the pure metals introduce many extravagances. Even if these extravagances may be overlooked as regards the loss of the metals as such, they are extremely important in connection with conserving other materials necessary to the process. When we consider that the steel industry of this continent produces annually over twenty million tons of steel, we may appreciate what a very minor improvement might mean in the way of conservation. The modern trend in this industry has been to study the possibilities of producing pig iron and steel in electric furnaces. For certain grades of steel this is eminently successful, and although not finally demonstrated as yet for pig iron, the world is greatly indebted to the Canadian Bureau of Mines, under the direction of Dr. Eugene Haanel, for extensive researches on "Electro-thermic Production of Pig Iron."

During recent years much painstaking research has been undertaken to control the hot acid smoke, laden with flue-dust and with vapors of poisonous sulphurous and arsenious compounds, which are discharged from the stacks of the various smelters. Several large copper smelters in the western part of the continent were forced by the Government to suspend operations, owing to the devastation of the surrounding country. A single smelter in California emitted more than one hundred thousand cubic feet of poisonous gas per minute. Prof. C. L. Parsons says that we discharge into the air through a single stack of the Washoe smelter as much sulphuric acid as is utilized throughout the whole continent. Considering that sulphuric acid is the basis of most of the important chemical industries and of the manufacture of fertilizers, the saving of this waste assumes an enormous importance. Very recently, as a result of a long painstaking research, several important processes have been and are being introduced at the smelters to save the useful products of these fumes. In this instance, however, as important as may be the saving of the materials, the really important conservation is that of the industry against its own self-destruction and of the valuable land which it was ravishing.

Only three years ago a leading scientific mind said: "The crest of our known resources of highest grade copper is already passed, and we are using lower and lower grades with increasing cost of production. The increasing inadequacy of our copper supply is a matter of deep concern." So rapid, however, has been the progress in the metallurgy of low grade copper, that it is now proving more profitable to work than was previously the case with the high grade ores. Indeed, although our production of copper has increased several hundred per cent in the last twenty-five years, and the annual output and consumption is still increasing, yet prices are lower than they were three years ago. This must

be credited to the greater efficiency of metallurgical processes, making possible the utilization of deposits formerly supposed to be worthless.

Even this brief review of some of the important points at which the experimental investigator touches the problems of conservation would be incomplete without mention of the recent and present work on peat by the Mines Branch, Canadian Bureau of Mines. Peat is a material found in extensive bogs, in nearly every province of Canada. As removed from the bogs it is unsuited for use as fuel, but after special treatment, including drying and briquetting, it makes excellent fuel. Some idea of the extent to which the utilization of this peat fuel deposit would conserve other forms of fuel, wood and coal, may be obtained from a recent low estimate of the peat resources of Canada as "equivalent to nearly 16,000,000,000 tons of coal."

Many of these problems of conservation may best be studied by the individual producers most concerned, but certain of the most important of them are essentially public problems. These have either been unsuccessfully attacked or not studied at all by the manufacturers. Such studies can best be undertaken by the people's institutions, the Government bureaus or the universities, often best by the co-operation of the two. It is a matter of common knowledge that in the manufacture of brass about 8 per cent of the total zinc is lost as vapor. No individual brass manufacturer, enormous and wealthy as many of them are, has been interested to expend the money and the time necessary to overcome this difficulty. The people ultimately pay for this loss of zinc in the increased price of brass. During the past year the U. S. Government, co-operating through its Bureau of Mines with Cornell University, has undertaken an extensive investigation of this process. Our own Government is not behind in recognizing the importance of the work to be accomplished by co-operating with Canadian Universities, and we of Queen's University are glad to feel that she is playing so important a part in carrying out extensive investigations for the Dominion Government on the effective utilization of certain of our own important natural mineral resources.

These are but a few of the savings which the research man has enabled those operating the various industries to bring about in recent years. Sometimes this saving is due to the utilization of new elements to replace old ones which are becoming exhausted; often it is brought about by supplying an entirely new compound or mechanism. Of the fifty metallic elements now known, there were only seven in commercial use two thousand years ago, viz., zinc, iridium, platinum, cobalt, nickel, antimony, cadmium and bismuth. That is, the rate of addition has been less than one metal for each two centuries prior to our century. Within our time, that is, during the last twenty-five years, there have been about fourteen metals added to commercial use, or the addition has been at a rate more than one hundredfold the previous rate.

A notion of the rapidity with which research has brought about changes in the various electro-chemical and metallurgical industries, is well illustrated by the statement of the president of one of our largest chemical corporations, that "progress in chemical industries is taking place so rapidly through the study of new processes, introducing new machinery, new methods and new materials, that my company has very little in the way of plant to-day which was in existence ten years ago." Whether we are proud of it or not, this is an industrial century and we are industrial people. New discoveries in our day are largely mental instead of geographical, and the old battles of conquest have become wars with ignorance. We are constantly attempting to broaden our mental horizon as our ancestors broadened their physical horizon.

### The Refinements of Detection

In spite of the extreme delicacy of many scientific tests, notably those in which the services of the spectroscope and the electroscope are enlisted, the eye and the nose are capable, in regard at any rate to some substances, of an equal refinement of detection; they can detect quantities as inconceivably small. When we reflect, for example, how great is the tinctorial power of some of the modern aniline dyes, it must be obvious that in very great dilutions when the eye still observes color the quantity of material present must be quite microscopic. Comparatively recently there has been introduced a series of dyes which ousted the eosins; they are known as the rhodamines, and yield magnificent red shades. The dye classed as G extra continues to show distinct color obvious to the eye in a solution when there can be present only, and probably less than, one ten billionth of a gramme. This means that in a milligramme of solution there is present at least one particle of color substance weighing less than 0.000,000,000,000,1 gramme. The sense of smell is

capable of detecting even smaller amounts of particles, for the presence of otto of roses in the air is readily recognized when only one third of a thousand billionth of a gramme (0.000,000,000,000,333 gramme) of the volatile oil is present in a cubic millimeter of air. It seems evident from this that the mere existence of an odor in the air can have very little chemical significance, and that any physiological effect it may produce (e. g., nausea) is a depressing one upon the nervous system, and not that of a toxic substance introduced into the blood stream. When the extremely minute quantities of substances which it is possible thus for the optic and olfactory nerves to detect are compared with the capabilities of, say, the spectroscope, it will be found that the human mechanism compares favorably with this instrument in regard to its powers of detection. The spectroscope is generally regarded with wonder because of the very minute quantities of substances which it will disclose. But when we find that in the case of neon it will detect the presence of 0.000,005 cubic centimeter, and in other examples

0.000,06 milligramme of strontium, 0.000,01 milligramme of lithium, and 0.000,000,3 milligramme of sodium, it will be seen that these quantities are gross compared with the detective powers of the human nerves. In, however, the scientific instrument used in electrical observations, the electroscope, the human agencies meet with a formidable competitor, for a delicate electroscope is nearly a million times more sensitive than a spectroscope. The modern instrument will detect one millionth of a millionth of a milligramme of radium. These refinements of detection suggest that they are capable of laying bare particles which are not matter at all, but energy; the infinitesimal is detected and weight, as we ordinarily know it, can scarcely enter into the calculation.

In this connection it is interesting to note the size of molecules. As B. J. Brown puts it in *School Science and Mathematics*, in one pound of water there are as many molecules as there would be packages, if the whole earth were divided up into parcels of one quarter of a pound a piece.—*The Lancet*.